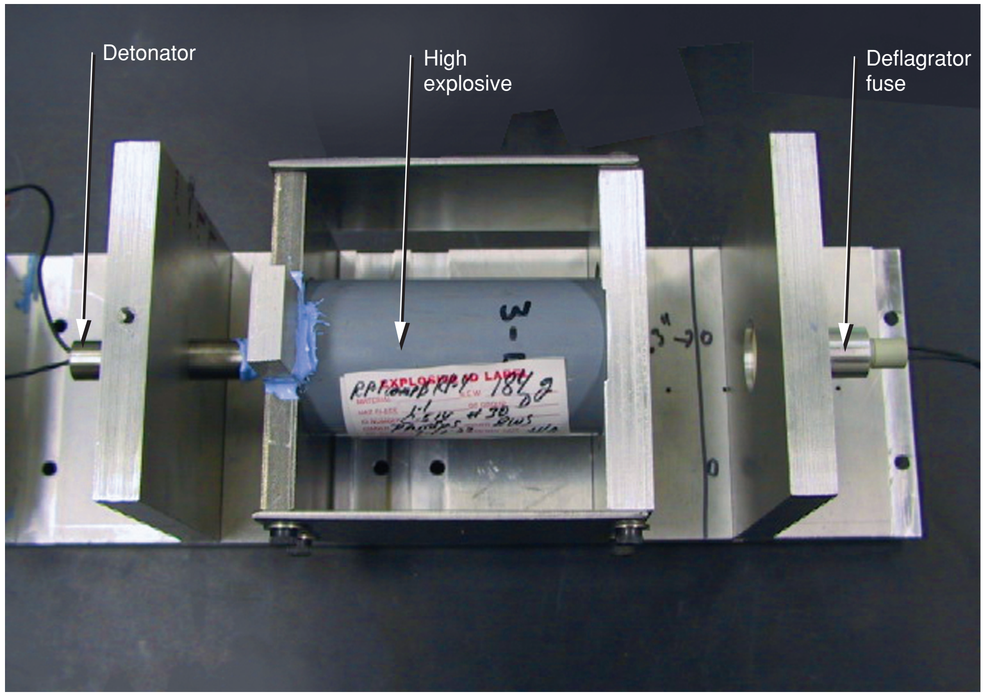
The Right Bang for the Job

WHEN you think of hand grenades, perhaps the first thing that comes to mind is a classic World War II (WWII) movie scene with a John Wayne–type hero leading his troops up a hill. At the top of the hill, the hero drops to his belly, pulls the pin from a hand grenade, and pitches it into an enemy bunker. Fast-forward half a century and warfare has changed dramatically, shifting from classical battlefields to urban conflicts that call for different tactics and armaments. The hand grenade, however, has remained largely unchanged.

Typically, U.S. soldiers are issued one-size-fits-all grenades to use in a variety of conflict environments and situations. This standard-issue grenade has a kill radius of about 5 meters and is designed for use against small fortifications and small groups of combatants. However, in some urban combat situations, this standard-issue grenade could be too powerful and could injure civilians and the soldiers using the grenades.

In recent years, U.S. soldiers have been increasingly engaged in urban warfare. These combat settings may have targets far different from a WWII-type machine-gun nest. Targets may include enemy quarters or weapons stockpiles housed in buildings set close to active civilian centers, such as schools, water facilities, or buildings of cultural or religious value. Combat situations also have become increasingly complicated. For example, a soldier may need to target a roomful of enemy combatants located next door to a roomful of hostages.

Imagine if a soldier could tailor a grenade's explosive force to the job at hand. With the turn of a dial, the soldier could set the kill radius of the grenade to a distance less than 5 meters and demolish the target while leaving civilians and nearby structures unscathed. Bill Bateson, a Livermore computational physicist at the Center for Applied Scientific Computing (CASC), has been designing such an adaptable hand grenade. The Laboratory's Defense and Nuclear Technologies (DNT) Directorate is funding the project through discretionary spending.



Photograph of the experimental apparatus used to test a yield-select hand grenade. A PVC cylinder the size of a soda can (center) is packed with a high explosive commonly used in grenades. A deflagrator fuse is attached to one end of the cylinder (right), and a detonator fuse is attached to the opposite end (left). A "witness" steel plate is used to seal the aluminum apparatus and measure the amount of damage done by the explosion.

Using Deflagration to Tailor a Yield

In a departure from the conventional grenade design, Bateson proposes adding a deflagrator to burn a preselected amount of high explosive (HE) before the detonator is set off. The concept is based on an idea that a grenade's burning of HE can be separated into two phases—a deflagration (quick-burning) phase that first consumes HE followed by the standard detonation (rapid-explosion) phase. The burning of HE during deflagration would lead to a less violent reaction and, thus, less destruction than would be caused by a full-yield explosion.

The seed for yield select was planted when Bateson—not usually a weapons designer—was doing computational modeling of conventional HE. “I was playing with ideas,” says Bateson. “How does HE work? How does one get it to detonate? How does one get it to deflagrate? I thought of experiments that could help us understand how HE works.” Later, in a conversation with an Army colonel, Bateson recognized the need for yield selection. “I realized that Livermore could provide this technology.” Management in both CASC and DNT agreed that developing yield-select technology could benefit the Laboratory and, in a cooperative effort, gave Bateson the go-ahead.

Proving the Principle

To date, Bateson has demonstrated proof of principle with a contraption that simulates a grenade. A PVC cylinder about the size of a soda can is packed with Comp-B, which is an HE commonly used in grenades. A deflagrator fuse is attached to one end of the cylinder, and a detonator fuse is attached to the opposite end. This assembly is fitted into an aluminum apparatus the size of a shoe box to which a diagnostic “witness” plate of steel is attached to seal the apparatus. The witness plate is used as a measure of the amount of damage done by the explosion. The assembly is then set to detonate after a predetermined time delay that allows for the deflagration reaction. During that time delay, the excess HE burns in the deflagration phase, leaving less explosive for the detonation phase.

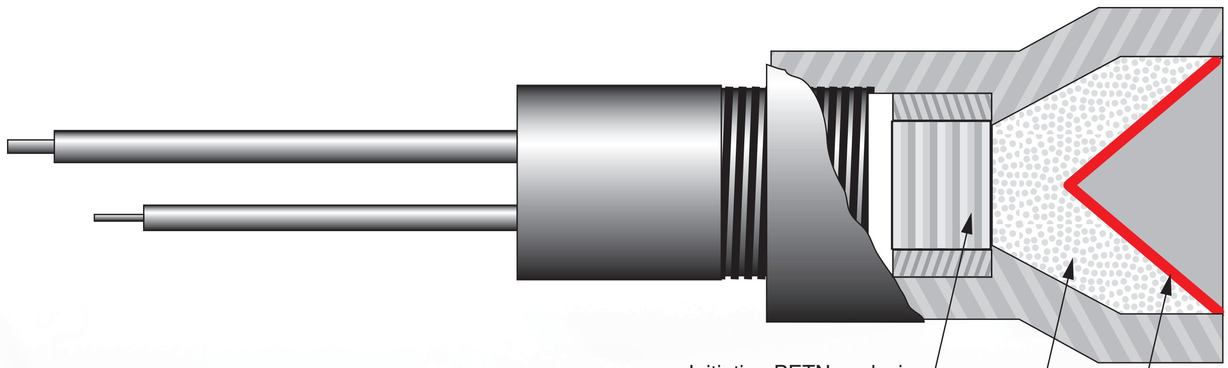
Bateson has experimented with varying detonation time delays following deflagration. He also has achieved full deflagration in which no detonation occurs and full detonation in which there is no time delay for deflagration. The witness plates tell the story of the varying degrees of deflagration. At full deflagration, where no explosion is expected because the entire HE has burned, the witness plate appears unscathed. At full detonation, however, the plate is considerably damaged and has a characteristic angled bend exhibited by all plates from experiments involving a detonation. As expected, witness plates from explosions set for longer deflagration phases show less damage and bend.

The steel “witness” plates show the range of effects from full deflagration (left) to full detonation (right) of a yield-select grenade.

The idea of yield select is not new. Researchers have been pondering possible designs for some time. One of the design challenges has been to initiate the deflagration reaction, while preventing the HE from detonating. Bateson overcame this obstacle with one small modification to a detonator fuse. The detonator is a shaped-charge explosive train, which means it has a liner between the initiating explosives and the main charge. The liner forms a “jet” when the initiating explosives (PETN and RDX) ignite. These initiating explosives launch the jet into the HE (Comp-B) in the grenade cylinder, which causes the HE to ignite. The liner in a standard detonator is made from copper, which triggers detonation. Bateson reasoned that if the copper liner were substituted with another material, deflagration could be achieved. Hence, the detonator could be used as a deflagrator. Indeed, when this theory was tested, the modified shaped-charge fuse created a jet that set off a deflagration instead of a detonation when it hit the Comp-B.

Just Getting Started

Despite the early success and excitement about yield select, much more work is needed to refine the system. “We’re in the first stages of design,” says Bateson. “People are asking if we can design a handheld-size yield-select grenade. The answer is yes.” Bateson sees size-slimming opportunities for both the deflagrator fuse and detonator fuse. By trimming down these fuses a few centimeters each, the yield-select hand grenade could be close to the size of currently manufactured



This schematic shows the newly designed deflagration fuse, which is a shaped-charge explosive train.

hand grenades. These new grenades would fit into existing grenade casings, shortening the time required to advance the new technology into the field.

The corollary to the size question is how scalable is yield select? "The Air Force wants a 2,000-pound yield-select bomb," says Bateson. "Now, the question is how do we scale up from a hand grenade? Do we use one large deflagrator or a chain of smaller deflagrators?"

In a recent directive to the secretaries of all military branches, the Office of the Secretary of Defense (OSD) stated that in the continuing pursuit of reducing collateral damage to civilians and civilian structures, all current ammunitions are to be considered for yield-select capability. "The OSD wants anything that hits the ground—bombs, grenades, mortars, rockets, or artillery shells—to be yield select," says Bateson." Clearly, the demand for yield select is big.

—Maurina S. Sherman

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